Active Project (2011 - 2016)

Unmanned Aircraft Systems Integration in the National Airspace System Project

Aeronautics Research Mission Directorate (ARMD)

ABSTRACT

The goal of the Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project is to provide research findings to reduce technical barriers associated with integrating UAS into the NAS utilizing integrated system level tests in a relevant environment. These barriers include: a lack of sense-and-avoid concepts and technologies that can operate within the NAS, robust communication technologies, robust human systems integration, and a relevant environment for use in testing the developed technologies.

ANTICIPATED BENEFITS

To NASA funded missions:

These activities support research within the Aeronautics strategic thrust area 6:

- Research findings to develop and validate UAS MOPS for SAA performance interoperability.
- Research findings to develop and validate UAS MOPS for terrestrial C2 communication.
- Research findings to develop and validate HSI GCS guidelines enabling implementation of the SAA and C2 performance standards.
- A relevant test environment that is a LVC-DE, for use in generating research findings to develop and validate HSI guidelines, DAA, and C2 MOPS with test scenarios supporting integration of UAS into the NAS.

Additionally, this Project will benefit the Science Mission Directorate Missions by enabling their UAS to fly on an as-needed basis through file and fly process verses the current FAA certificate of waiver/authoriziation process.

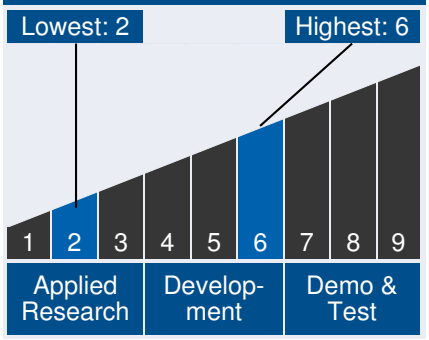
To other government agencies:

This project provides an opportunity to transition concepts, technologies, algorithms, and knowledge to the Federal Aviation

NASA's Ikhana , an unmanned aerial vehicle, represents the type of civil aircraft that needs to be safely integrated into the national airspace.

Table of Contents

Technology Maturity



Unmanned Aircraft Systems Integration in the National Airspace System Project

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Administration (FAA) and other stakeholders to help them define the requirements, regulations, and issues for routine UAS NAS access.

To the nation:

The goal of the UAS Integration in the NAS Project is to provide research findings to reduce technical barriers associated with integrating UAS into the NAS utilizing integrated system level tests in a relevant environment.

DETAILED DESCRIPTION

There is an increasing need to fly Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) to perform missions of vital importance to national security and defense, emergency management, science, and to enable commercial applications. However, routine access by UAS to the NAS remains unrealized.

The UAS community needs routine access to the global airspace for all classes of UAS. Based on this need, NASA's UAS Integration in the NAS Project identified the following goal: To provide research findings to reduce technical barriers associated with integrating UAS into the NAS utilizing integrated system level tests in a relevant environment. These barriers include: a lack of sense-and-avoid concepts and technologies that can operate within the NAS, robust communication technologies, robust human systems integration, and a relevant environment for use in testing the developed technologies.

The project's goal will be accomplished by developing system-level integration of key concepts, technologies and/or procedures, as well as demonstrating those integrated capabilities in an operationally relevant environment.

The project conducts research to address technical barriers in the following areas:

Management Team

Program Director:
- Edgar Waggoner

Project Manager:
- Laurie Grindle

Principal Investigators:
- Maria Consiglio
- James Griner
- Sam Kim
- James Murphy
- Confesor Santiago
- Robert Shively

Technology Areas

- Communication & Navigation (TA05)
- Modeling, Simulation, Information Technology & Processing (TA11)
- Aeronautics (TA15)

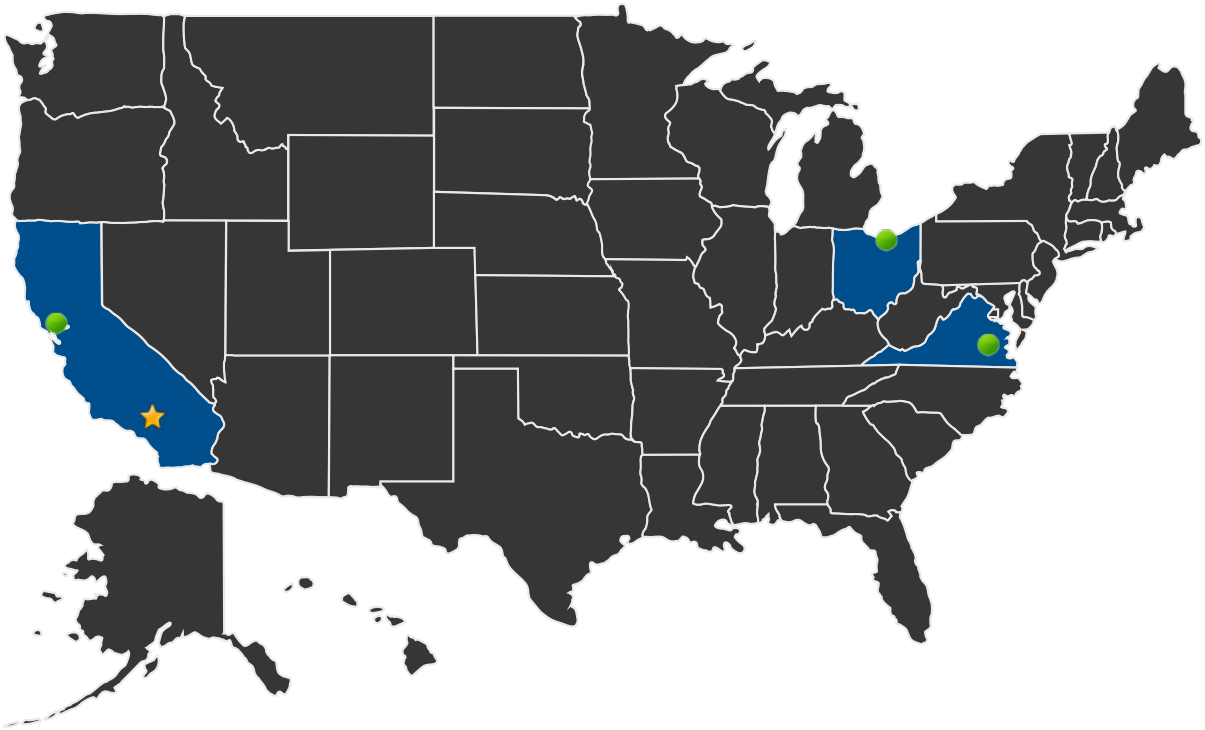
Unmanned Aircraft Systems Integration in the National Airspace System Project

Aeronautics Research Mission Directorate (ARMD)

- Sense and Avoid (SAA) [synonymous with Detect and Avoid (DAA)] Performance Standards: Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for SAA performance and interoperability.
- Command and Control (C2) Performance Standards: Provide research findings to develop and validate UAS MOPS for terrestrial C2 communication.
- Human Systems Integration (HSI): Provide research findings to develop and validate HSI ground control station (GCS) guidelines enabling implementation of the SAA and C2 performance standards.
- Integrated Test and Evaluation (IT&E): Develop a relevant test environment that is a live virtual constructive (LVC) distributed environment (DE), for use in generating research findings to develop and validate HSI guidelines, DAA, and C2 MOPS with test scenarios supporting integration of UAS into the NAS.

These activities support research within the aeronautics strategic thrust area 6.

U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Armstrong Flight Research Center

Supporting Centers:

- Ames Research Center
- Glenn Research Center
- Langley Research Center

Other Organizations Performing Work:

- Department of Defense
- Federal Aviation Administration

Contributing Partners:

- Department of Defense
- Federal Aviation Administration

PROJECT LIBRARY

Conference Papers

- A Formally Verified Conflict Detection Algorithm for Polynomia
  - (http://techport.nasa.gov:80/file/6580)
- A Systems-Based Approach to Functional Decomposition and Allocation for Developing UAS Separation Assurance Concepts
  - (http://techport.nasa.gov:80/file/6574)
- A TCAS-II Resolution Advisory Detection Algorithm
  - (http://techport.nasa.gov:80/file/6571)
- AIAA Aviation 2014 Exploration of the Trade Space Between UAS Descent Maneuver Performance and SAA System Performance Requiremen
  - (http://techport.nasa.gov:80/file/6578)
- Concept of Integration for UAS Operations in the NAS
  - (http://techport.nasa.gov:80/file/6570)
- Effects of UAS Mission Type and Performance Characteristics on NAS Operations
  - (http://techport.nasa.gov:80/file/6572)

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Conference Papers *(cont.)*

- Exploration of the Trade Space Between UAS Descent Maneuver Performance and SAA System Performance Requirements -NASA CR
  - (http://techport.nasa.gov:80/file/6576)
- Investigating Detect and Avoid Surveillance Performance for Unmanned Aircraft Systems
  - (http://techport.nasa.gov:80/file/6575)
- Investigating Effects of Well Clear Definitions on UAS SAS Operations in Enroute and Transition Airspace
  - (http://techport.nasa.gov:80/file/6573)
- Investigating the Impacts of a Separation Standard for UAS Enroute and Transition Airspace
  - (http://techport.nasa.gov:80/file/6579)
- Pilot Evaluation of a UAS Detect and Avoid Systems Effectiveness in Remaining Well Clear
  - (http://techport.nasa.gov:80/file/6581)
- Report -A Family of Well-Clear Boundary Models for the Integration of UAS in the NAS
  - (http://techport.nasa.gov:80/file/6577)
- UAS-NAS Survey Responses by ATC Manned Aircraft Pilots and UAS Pilots
  - (http://techport.nasa.gov:80/file/6582)

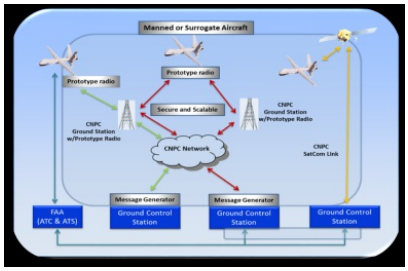
Peer Reviewed Papers

- Control and Non-Payload Communications Links for Integrated Unmanned Aircraft Operations
  - (http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120016398.pdf)

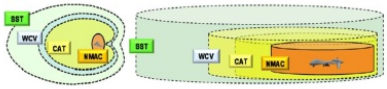
Videos

- NASA X: Unmanned Aircraft Systems-Transforming the Horizon
  - (http://www.youtube.com/watch?v=XMr9W6WYWcc)

IMAGE GALLERY

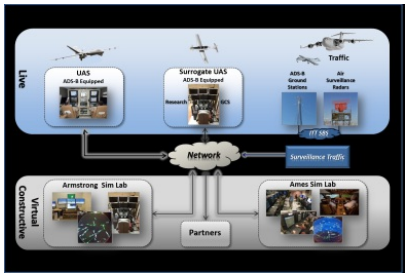


UAS-NAS Projects C2 Communication Architecture



Collision Avoidance Threshold (CAT)- The boundary around the UA at which the Collision Avoidance Function (CAF) declares that action is necessary to avoid a collision by preventing the threat from penetrating the collision volume .

Ikhana Simulator at NASA Armstrong



This graphic illustrates the LVC-DE, which generates simulated air traffic

NASA Dryden student intern Gary Bell flies the MQ-9 Ikhana pilot simulator during LVC-DE system testing

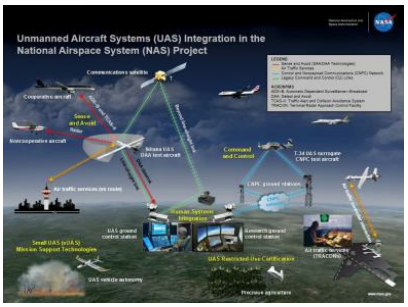
NASA Dryden engineers Martin Hoffman (foreground) and Jamie Wilhite monitor LVC-DE displays during recent system testing

NASA's Ikhana in flight

S-3B Viking at NASA Glenn

T-34C at NASA Glenn

Pilot Control Station Layout for Flight Test



Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

DETAILS FOR TECHNOLOGY 1

Technology Title

1. Sense and Avoid Performance Standards

Technology Description

This technology is categorized as an architecture for unmanned flight

The goal within this technical challenge is to provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for sense and avoid (SAA) performance and interoperability.

Work includes determining the required performance of candidate SS and CA algorithms, SAA surveillance system requirements, and the performance characteristics of and interactions between SAA sub-functions. It also includes supporting the definition of sensor and algorithm-agnostic maneuverability requirements, and evaluating of the impact of sensor uncertainties and vehicle performance limitations on the execution of SAA maneuvers.

Capabilities Provided

- UAS performance models & scenarios

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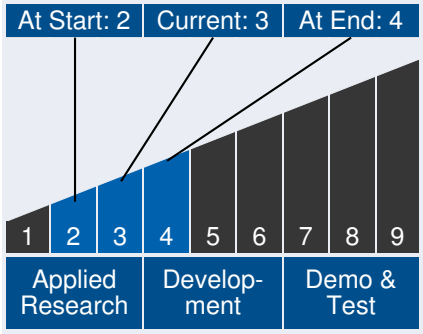
Technology Maturity



Capabilities Provided *(cont.)*

- Fast-time SAA testbed (ACES)
- Evaluations of definitions of well clear and recommendations on which to employ
- Description of the concept of operations for SAA
- Data, results, and technical reports from analysis, studies, batch simulations, HITLs, IHITL, and flight tests
- SAA requirements and recommendations for DAA MOPS

Potential Applications

This technology will support the development of Minimum Operational Performance Standards (MOPS) being drafted by RTCA Special Committee 228. The MOPS will then be delivered to the Federal Aviation Administration (FAA) who will convert the information into Technical Standards Orders (TSO). The TSO can then be used by Industry to build hardware and software that meets the requirements.

DETAILS FOR TECHNOLOGY 2

Technology Title

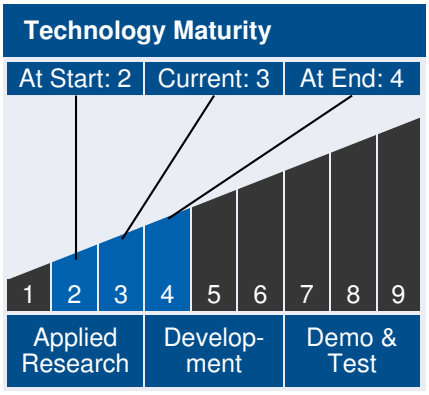
2. Command and Control Performance Standards

Technology Description

This technology is categorized as an architecture for unmanned flight

The goal within this technical challenge is to provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for terrestrial command and control (C2) communication.

Work includes developing and flight testing a prototype terrestrial control and non-payload communication (CNPC) system to develop and validate performance requirements. It also includes conducting analysis and proposing CNPC security recommendations for civil UAS operations, performing UAS Spectrum analysis and testing, and developing a simulation environment to perform analysis of a UAS CNPC system and validate the simulation.



Capabilities Provided

- Results from CNPC System prototype performance in Relevant Environment and mixed traffic environment
- Analysis, test results, and recommendations of CNPC security architecture performance
- Propagation environment channel models for terrestrial CNPC spectrum bands
- NAS-wide UAS LOS (Line of Sight) CNPC system simulation results of Interim (low-medium fidelity) and CNPC link (high fidelity) communications models
- ATC and CNPC communications performance impact on delays/capacity of the NAS report and models

Potential Applications

This technology will support the development of Minimum Operational Performance Standards (MOPS) being drafted by RTCA Special Committee 228. The MOPS will then be delivered to the Federal Aviation Administration (FAA) who will convert the information into Technical Standards Orders (TSO). The TSO can then be used by Industry to build hardware and software that meets the requirements.

DETAILS FOR TECHNOLOGY 3

Technology Title

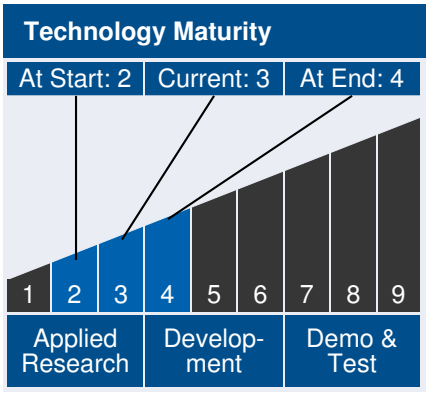
3. Human Systems Integration

Technology Description

This technology is categorized as an architecture for unmanned flight

The goal within this technical challenge is to provide research findings to develop and validate human systems integration (HSI) ground control station (GCS) guidelines enabling implementation of Sense and Avoid, and Command and Control performance standards.

Work includes developing human factors guidelines including displays, controls, and procedures for operation in the NAS. The overall GCS guidelines will be comprehensive, but will have a specific focus on guidelines for SAA and C2 MOPS. It also includes developing an instantiation of a Research Ground Control Station (RGCS) for use in subproject and integrated



testing events.

Capabilities Provided

- Research Ground Control Station (RGCS) that will instantiate the GCS guidelines and serve as GCS for the integrated events
- Guidelines for GCS design and operation in the NAS
- Apply GCS guidelines towards DAA and C2 MOPS

Potential Applications

This technology will support the development of Minimum Operational Performance Standards (MOPS) being drafted by RTCA Special Committee 228. The MOPS will then be delivered to the Federal Aviation Administration (FAA) who will convert the information into Technical Standards Orders (TSO). The TSO can then be used by Industry to build hardware and software that meets the requirements.

DETAILS FOR TECHNOLOGY 4

Technology Title

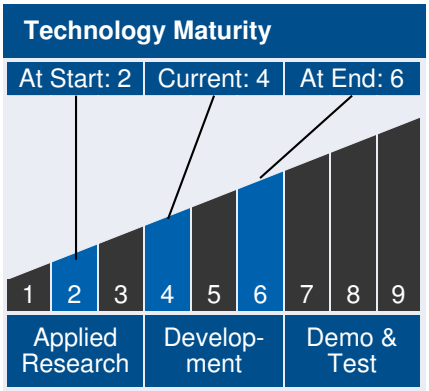
4. Integrated Test and Evaluation

Technology Description

This technology is categorized as an architecture for ground support or mission operations

The goal within this technical challenge is to develop a relevant test environment for use in generating research findings to develop and validate human systems integration (HSI) Guidelines, sense and avoid (SAA), and command and control (C2) minimum operational performance standards with test scenarios supporting integration of UAS into the NAS.

Work includes developing an integrated test environment to develop, test, and explore key challenges and technology objectives of the subprojects technology, as well as developing concepts, technologies, and capabilities to be used to evaluate the overall operation of UAS in the NAS in a relevant environment, and lead the test planning of the integrated test events.



Capabilities Provided

- A Live Virtual Constructive (LVC) Distributed Test Environment to integrate and test and validate technologies in a relevant environment

Potential Applications

A long term NASA capability that will allow NASA, other Government Agencies, and Industry to tie into the LVC network and perform simulations or live flight testing against other aircraft.